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Importance of landfills to urban-nesting herring and ring-billed gulls

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Abstract

Little information exists on the importance of landfills to urban gulls and the influence landfills have on the establishment of urban-nesting gull colonies. Thus, there is critical need for data to determine factors contributing to increasing populations of urban gulls. Our objectives were to determine the importance of landfills to the reproductive success, diet, and movements (via radio telemetry) of urban-nesting herring gulls (*Larus argentatus*) and ring-billed gulls (*L. delawarensis*) in northern Ohio. Hatch success of herring gulls (198 breeding pairs) and ring-billed gulls (4502 breeding pairs) at urban-nesting colonies was $\geq$41% lower than hatch success of traditional Great Lakes nesting colonies and more closely approximated hatch success of other urban-nesting colonies. Based on diet and habitat use, ring-billed gulls appeared more dependent on landfills than did herring gulls. Anthropogenic food, primarily from three landfills, was the major component of the diets of ring-billed gulls, whereas fish, primarily from Lake Erie, was used more extensively by herring gulls. On average, adult (25 km) and hatching-year (24 km) ring-billed gulls were located farther from their nesting colony than were adult (18 km) or hatching-year (12 km) herring gulls. Habitat use by hatching-year gulls of both species was similar to habitat use by adult conspecifics. Landfills contain a dependable source of food for urban-nesting gulls. Thus, size and distribution of urban-nesting gull colonies are likely to continue increasing, provided adequate anthropogenic food and colony sites remain available.

Keywords: Herring gull; *Larus argentatus*; *L. delawarensis*; Ring-billed gull; Urban planning; Waste disposal facilities

1. Introduction

Populations of several species of gulls have increased throughout North America in recent years (Drury and Kadlec, 1974; Conover, 1983; Belant and Dolbeer, 1993). In the Great Lakes region, both breeding and winter populations of herring gulls (*Larus argentatus*) and ring-billed gulls (*L. delawarensis*) have increased dramatically. For example, the nesting population of ring-billed gulls along the Canadian portion of the lower Great Lakes increased from about 56 000 pairs to 283 000 pairs between 1976 and 1990; herring gulls increased from 440 to 1300 pairs during these same years (Blokpoel and Tessier, 1991). Winter populations of ring-billed and herring gulls along the south shore of Lake Erie increased 21- and 6-fold, respectively, from the 1950s to the early 1980s (Dolbeer and Bernhardt, 1986).

Suspected causes for these increased gull populations include the protection of breeding colonies (Kadlec and Drury, 1969), an increase in nesting

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habitat from the creation of dredge disposal islands (Patton and Hanners, 1984), and exploitation of landfills by gulls as dependable sources of food (Verbeek, 1977; Burger, 1981; Patton, 1988; Belant and Dolbeer, 1993).

Sanitary landfills frequently attract large numbers of gulls and other birds, at least seasonally (Horton et al., 1983; Patton, 1988; Belant et al., 1995). Although there is general agreement that anthropogenic food (i.e., garbage) at landfills contributes overall to the diet of herring and ring-billed gulls (Kihlman and Larsson, 1974; Pierotti and Annett, 1987; Patton, 1988; Pons, 1992; Belant et al., 1995), there are conflicting conclusions from previous studies regarding the importance of anthropogenic food to gulls during the breeding season. Several authors have suggested that the availability of garbage increases (Kadlec and Drury, 1969; Hunt, 1972; Pons, 1992), or is essential for (Sibley and McCleery, 1983), the reproductive success. In contrast, Pierotti and Annett (1987) have suggested that garbage is a low-quality food compared to other 'natural' foods, and could reduce reproductive success.

Because landfills are often located near urban areas, their increased use by gulls and associated urban nesting has caused a concurrent increase in conflicts with humans. These conflicts include transmission of pathogens and parasites through contamination of water sources and upland habitat (Mudge and Ferns, 1982; Butterfield et al., 1983), damage to buildings (Vermeer et al., 1988; Belant, 1993), and a hazard to aircraft at airports (Dolbeer et al., 1993).

Our objectives were to determine reproduction, diet, distance from nesting colonies, and habitat use of urban populations of herring and ring-billed gulls during incubation, chick-rearing, and post-fledging, and to determine the importance of landfills to populations of urban-nesting herring and ring-billed gulls.

2. Study areas

The study was conducted from late April to August 1995, primarily in Cuyahoga County, Ohio. Located on Lake Erie, Cuyahoga County has a human population of 1 400 000, of which about 33% reside in Cleveland. Cuyahoga County produces approximately 1 675 000 t of residential and commercial waste annually (Cuyahoga County Planning Commission, 1993). Much of this waste is distributed among five public landfills, primarily the Cuyahoga Regional Sanitary Landfill (CRSL) in Solon, 26 km south of Lake Erie, which receives about 1000 t daily. The Glenwillow Landfill (Cuyahoga County) and Painesville Landfill (Lake County) are 27 and <1 km from Lake Erie, respectively.

Dock 20, operated by the Port Authority of Cleveland, is located immediately northwest of downtown Cleveland adjacent to Lake Erie. Nesting ring-billed and herring gulls had not been reported at Dock 20 prior to 1995. This colony was apparently formed as a consequence of nest disturbance programs conducted at several roof-nesting gull colonies throughout Cuyahoga County (e.g., ArgoTech, which contained 115 and 736 herring and ring-billed gull nests, respectively; see Ickes and Belant, 1998). The nesting colony at Dock 20 was primarily on a gravel berm 200 m × 15 m. A small portion of the colony extended onto a flat gravel surface. Dock 20 is 24, 26, and 34 km from the CRSL, Glenwillow, and Painesville Landfills, respectively. Burke Lakefront Airport (BLA) is about 2 km from Dock 20.

Microsheen is in Euclid, Ohio, 2.8 km south of Lake Erie and 17 km northeast of Dock 20. Microsheen contained the largest herring gull nesting colony in Cuyahoga County. The 1.7 ha roof of Microsheen contained numerous structures (e.g., vents, skylights) on a primarily light-colored gravel surface. The roof of this building has six distinct sections, the heights of which vary $\leq$2 m. Microsheen is 23, 26, and 20 km from the CRSL, Glenwillow, and Painesville Landfills, respectively. Microsheen is 18 km from BLA.

3. Methods

3.1. Population estimation and reproduction

We estimated the nesting population of herring gulls at Microsheen by conducting complete counts of nests containing $\geq$1 egg or chick on 14 April then weekly from 10 May to 31 August. During each visit, we recorded the number of eggs and chicks in each nest. We also counted the number of chicks not at a nest. Mean date of initial incubation was estimated by interpolation of consecutive nest counts between which 50% of nests with $\geq$1 egg occurred. We defined the length of incubation as 28 days after mean initiation of incubation and the length of chick-rearing as 42 days post-incubation (Paynter, 1949; Kadlec et al., 1969; Drent, 1970; Haycock and Threlfall, 1975; Pierotti, 1982). Post-fledging data were collected through 31 August. Minimum hatch success was defined as the maximum number of unfledged chicks/maximum number of nests; minimum fledging success was defined as the maximum number of chicks observed during post-fledging/maximum number of nests.

We estimated the nesting population of ring-billed gulls and herring gulls at Dock 20 by conducting three complete counts of nests on 12, 19, and 26 May and two partial ground counts on 16 June ($n = 550$), and 7 July ($n = 320$) to determine stage of nesting. During each complete count (except 26 May), we recorded the total number of nests (nests containing $\geq$1 egg and/or chick) for each species; during each partial count (and on 26 May), we recorded the number of nests with $\geq$1 egg or chick. Mean hatch date for ring-billed gulls was estimated by interpolation of consecutive nest counts between which 50% of nests with $\geq$1 chick occurred. We defined the length of incubation and chick-rearing as 26 and 35 days before and after mean hatch date (Vermeer, 1970; Kirkham and Morris, 1979; Boersma and Ryder, 1983; Ryder, 1993). Minimum hatch success for ring-billed gulls was estimated by determining the proportion of nests with $\geq$1 chick. At Dock 20, hatch success was not estimate for herring gulls and minimum fledging success was not determined for either species.

3.2. Diet

To determine the diet of nesting herring and ring-billed gulls, we collected pellets and food remains at Microsheen and Dock 20. Seven 1 m-wide transects were established at Microsheen, each of which occurred within the primary herring gull nesting area. Ten transects were established similarly within the primary ring-billed gull nesting area at Dock 20. Concurrent with nest counts at each respective colony, all food items (pellets and food remains) were removed from each transect, placed in plastic bags, and later weighed and/or identified. Each food item was classified into one of several natural (e.g., fish, mammal) or anthropogenic (e.g., chicken bones, beef or pork rib bones [hereafter chicken or ribs]) food types. We also recorded presence of anthropogenic non-food items (e.g., paper, plastic) in pellets and food remains.

Presence of food types in pellets was expressed as percent frequency of occurrence and pooled by reproductive period. For food remains, the mass (g) of each food type was determined and expressed as a percent of the total food remains by reproductive period.

3.3. Capture and marking

We captured and attached radio transmitters to 41 adult (24 herring, 17 ring-billed) and 40 hatching-year birds (20 herring, 20 ring-billed). We captured 21 and two nesting ring-billed and herring gulls, respectively, on ArgoTech, and 15 nesting herring gulls on Microsheen using walk-in traps (Weaver and Kadlec, 1970) from 24 April to 3 May. On 8 May, three nesting ring-billed gulls were captured at BLA using a rocket net. Because of nest destruction projects at Argotech and BLA, seven radio-marked ring-billed gulls renested at Dock 20 (see Ickes and Belant, 1998). We captured 20 hatching-year herring gulls at Microsheen (23 June) and 20 hatching-year ring-billed gulls at Dock 20 (30 June) using dip nets. Hatching-year birds captured were considered at or near fledging (late stage 3B or stage 4; Kadlec et al., 1969).

Herring and ring-billed gulls were each banded with a U.S. Fish and Wildlife Service leg band (sizes 6 and 4A, respectively) and an orange plastic leg band (A.C. Hughes, Middlesex, UK), then fitted with a back-mounted radio transmitter (Advanced Telemetry Systems, Inc., Isanti, Minn.) using 6 mm wide teflon ribbon for a harness. Herring gull and ring-billed gull radio transmitter packages weighed approximately 30 and 18 g, respectively, representing <4% of body mass for each species. Mean body mass for herring and ring-billed gulls were about 1050 and 460 g, respectively.

3.4. Telemetry

We monitored radio-marked gulls from 12 May to 31 August using standard aerial telemetry techniques (Mech, 1983). Aerial telemetry was conducted 1–5 days/week, typically during daylight hours. Aerial locations were estimated in latitude and longitude using a Global Positioning System (Garmin Int., Lenexa, Kans.) then converted to Universal Transverse Mercator Grid System coordinates. Additional data recorded for each gull location included date, time, and habitat when possible. We determined the mean distance (km) each species of gull by age class was located away from their respective nesting colony during incubation, chick-rearing, or post-fledging. We were unable to relocate one adult herring gull and two hatching-year ring-billed gulls; thus, these gulls were excluded from all analyses. We used the General Linear Models (GLM) Procedure (SAS Institute, 1988) with Tukey multiple comparison tests to compare movements of radio-marked gulls. Data violating the assumption of normality were log transformed ($\log(X+1)$) (Zar, 1984) prior to analysis.

4. Results

4.1. Population estimates and reproduction

The maximum number of herring gull nests (198) at Microsheen occurred on 17 May. We determined incubation, chick-rearing, and post-fledging periods as 23 April–20 May, 21 May–1 July, and 2 July–31 August, respectively. Estimated minimum hatch and fledge rates were 1.2 and 0.32 chicks/nest, respectively. The maximum number of ring-billed gull nests (4502) at Dock 20 occurred on 26 May. We determined incubation, chick-rearing, and post-fledging periods as 16 May–10 June, 11 June–15 July, and 16 July–31 August, respectively. Estimated minimum hatch success of ring-billed gulls was 0.73 chicks/nest.

4.2. Diet

Natural food items occurred in 92% of herring gull pellets ($n=691$) collected from Microsheen during each reproductive period (Table 1). Fish was the most prevalent food type, represented in 82% of pellets overall. Frequency of occurrence of vegetation, insects, and birds in pellets followed fish in overall importance. Anthropogenic items occurred in 20% of herring gull pellets overall. The primary anthropogenic food type in pellets by reproductive period was chicken (9%).

Natural and anthropogenic food remains represented 27% and 71%, respectively, of mass collected at the herring gull colony. Fish comprised 93% of natural food remains collected. All other natural food remains occurred infrequently ($\leq$1%). Primary anthropogenic food remains period were chicken (43%) and ribs (24%).

Overall, anthropogenic items occurred in about 54% of ring-billed gull pellets collected from Dock 20. Chicken was the only anthropogenic food type recorded (29% occurrence overall). Overall, natural food occurred in 75% of ring-billed gull pellets ($n=28$). Insects (43%) and fish (39%) were represented about equally overall, followed by birds (14%) and vegetation (14%).

Anthropogenic food items represented 99% of mass of food remains collected at the ring-billed gull colony overall. In contrast, natural food items represented 2% of mass of food remains collected. Primary anthropogenic food remains were chicken (73%) and ribs (24%); the primary natural food remain was fish (1%).

4.3. Flight radius

Adult herring gulls traveled greater ($F=8.76$; d.f. $=1136$; $p<0.01$) distances (17.9 km) from the nesting colony on average than did hatching-year herring gulls (11.9 km) (Table 2). In contrast, mean distances adult and hatching-year ring-billed gulls travelled from the colony (25.3 and 24.2 km, respectively) were similar ($F=0.01$; d.f. $=1144$; $p=0.93$). Overall, adult and hatching-year ring-billed gulls were located farther from their nesting colony than were adult herring gulls ($p<0.05$, Tukey test). There was no difference ($F=0.26$; d.f. $=2280$; $p=0.77$) in distances adult herring and ring-billed gulls were located from their respective nesting colonies among reproductive periods. The interaction of species and reproductive period was not significant ($F=0.08$; d.f. $=2280$; $p=0.92$).

4.4. Habitat Use

Overall, landfills were used more frequently by adult (77% of total locations) and hatching-year (89%) ring-billed gulls than by adult (34%) or hatching-year (29%) herring gulls (Table 3). However, use

Table 1
Occurrence (%) of food items in pellets and mass (%) of food remains by reproductive period, from herring and ring-billed gull colonies, Cuyahoga County, OH, May–August 1995

Food type	Herring gulls at Microsheen								Ring-billed gulls at Dock 20							
	Incubation		Chick-rearing		Post-fledging		Combined		Incubation		Chick-rearing		Post-fledging		Combined	
	Pellets	Remains	Pellets	Remains	Pellets	Remains	Pellets	Remains	Pellets	Remains	Pellets	Remains	Pellets	Remains	Pellets	Remains
Natural	94	23	93	38	91	19	92	27	100	12	79	2	33	<1	75	2
Fish	87	23	79	35	83	18	82	25	100	9	42	2	0	<1	39	1
Insects	8	0	18	<1	10	0	12	<1	0	0	46	<1	33	0	43	<1
Birds	10	0	6	2	5	<1	6	1	0	0	13	0	33	0	14	0
Vegetation	10	0	19	<1	10	0	13	<1	0	0	17	0	0	0	14	0
Crayfish	0	<1	0	<1	<1	<1	<1	<1	0	3	0	0	0	0	0	<1
Mammals	0	0	0	1	0	<1	0	<1	0	0	0	0	0	0	0	0
Anthropogenic	19	70	19	61	21	80	20	71	100	88	46	98	100	100	54	99
Non-food	13	0	16	6	17	2	16	3	0	<1	42	<1	100	1	46	<1
Chicken	12	39	8	31	9	54	9	43	100	88	25	71	33	77	29	73
Ribs	2	31	0	24	1	23	1	24	0	0	0	25	0	22	0	24
Other	0	0	0	<1	2	2	1	1	0	0	0	0	0	0	0	0
Unknown	0	7	1	<1	<1	<1	<1	1	0	0	4	0	0	0	4	0
n (total mass [g])	52	450	193	1351	446	1714	691	3515	1	36	24	1312	3	686	28	2034

Table 2
Mean distance (km) radio-marked adult ($n = 16$) and hatching-year ($n = 15$) herring gulls and adult ($n = 24$) and hatching-year ($n = 18$) ring-billed gulls were located away from respective nesting colonies, Cuyahoga County, Ohio, May–August 1995

Age	Period[b]	Herring gull[a]			Ring-billed gull[a]		
		n	Mean	SD	n	Mean	SD
Adult	Incubation	1	17.4	–	10	24.4	10.8
	Chick-rearing	18	14.5	6.3	30	22.4	6.4
	Post-fledging	104	18.7	26.2	81	26.4	32.5
	Combined	123	17.9	24.2	121	25.3	27.0
Hatching-year	Post-fledging	17	11.9	8.8	27	24.2	8.0

[a] There was an interaction of species and age class ($F = 19.58$; d.f. $= 1280$; $p<0.01$).
[b] There was no difference among periods ($F = 1.18$; d.f. $= 2280$; $p = 0.31$).

of landfills by both species increased from incubation through post-fledging. Use of landfills by hatching-year herring and hatching-year ring-billed gulls was similar to use of landfills by adult conspecifics during post-fledging.

The CRSL, Glenwillow Landfill, and Painesville Landfill were the waste disposal facilities primarily used by herring and ring-billed gulls. Overall, CRSL was used more frequently than other landfills by both species and age classes of gulls (60% of landfill locations for adult herring gulls, 100% of locations for hatching-year herring gulls, 86% of locations for adult ring-billed gulls, and 92% of locations for hatching-year ring-billed gulls). Use of the Glenwillow Landfill was 21% and 0% for adult and hatching-year herring gulls, and 7% and 8% for adult and hatching-year ring-billed gulls, respectively. Use of the Painesville Landfill was 19% and 0% for adult and hatching-year herring gulls and 5% and 0% for adult and hatching-year ring-billed gulls, respectively. Adult ring-billed gulls were located once each at three other landfills, two in Cuyahoga County and one in Lake County.

Overall, Lake Erie was used extensively by adult (54% of total locations) and hatching-year (65%) herring gulls compared to limited use of Lake Erie by adult (6%) and hatching-year (7%) ring-billed gulls (Table 3). Use of Lake Erie by adult herring gulls remained relatively constant from incubation through post-fledging; however, use remained >50% during each reproductive period. In contrast, use of Lake Erie by adult ring-billed gulls did not exceed 10% during any reproductive period.

We located radio-marked adult ring-billed gulls and herring gulls at BLA 4 and 1 times, respectively.

5. Discussion

During this study, breeding pairs of herring gulls hatched on average a minimum of 1.2 chicks and fledged at least 0.32 chicks; ring-billed gulls hatched

Table 3
Habitat use (%) exclusive of respective nesting colonies by reproductive period for radio-marked adult ($n = 16$) and hatching-year ($n = 15$) herring gulls and adult ($n = 24$) and hatching-year ($n = 18$) ring-billed gulls, Cuyahoga County, Ohio, May–August 1995

Age	Period	Herring gull				Ring-billed gull			
		n	Landfill	Lake Erie	Other[a]	n	Landfill	Lake Erie	Other[a]
Adult	Incubation	1	0	100	0	10	60	10	30
	Chick-rearing	19	21	63	16	34	65	9	26
	Post-fledging	105	37	51	11	89	84	4	11
	Combined	125	34	54	12	133	77	6	16
Hatching-year	Post-fledging	17	29	65	6	27	89	7	4

[a]Other includes airports, roofs, ponds, rivers.

a minimum of 0.73 chicks/nest. These hatching and fledging success rates are lower than those reported for 'natural' colonies located on islands and breakwalls (Fetterolf, 1983; Belant, 1993; Belant and Seamans, 1993; Brown and Morris, 1994), and more closely approximate hatch rates reported for other urban-nesting gull colonies (Gabrey et al., 1993; Dwyer et al., 1994).

Use of inland feeding sites, as opposed to Lake Erie, may be of greater importance to nesting ring-billed gulls than to nesting herring gulls. In our study, nesting ring-billed gulls were located at landfills more frequently than were nesting herring gulls. Anthropogenic food also contributed more overall to the diet of ring-billed gulls, whereas fish was the primary food of herring gulls. Dwyer et al. (1994) found that ring-billed gulls nested farther from Lake Erie and depended more heavily on anthropogenic food than did herring gulls. Vermeer (1973) stated that the distribution of herring gulls in northern Canada was restricted to areas around large lakes because of their dependence on aquatic food sources. Also, Belant et al. (1993) found that herring gulls nesting on Sandusky Bay, Lake Erie (about 90 km from Cleveland) relied primarily on fish with anthropogenic food being of little importance.

Compared to herring gulls, ring-billed gulls appear more general in their selection of food items (Chudzik et al., 1994). In our study, fish was represented in only 42% of ring-billed gull pellets during chick-rearing. In contrast, fish was the predominant food item found in herring gull pellets, with an overall occurrence of about 80%. Also, the proportion of anthropogenic food remains collected at the ring-billed gull colony was greater than the proportion collected at the herring gull colony. Ring-billed gulls have been reported frequently to forage on insects and earthworms in agricultural areas (Vermeer, 1970; Ryder, 1993); such terrestrial items are uncommon generally in the diets of herring gulls (Belant et al., 1993; Gabrey et al., 1993; Dwyer et al., 1994).

For each species, use of landfills and Lake Erie was similar for adults and hatching-year birds. Use of landfills by hatching-year gulls of both species occurred soon after attaining flight and their use of landfills increased through post-fledging. In northcentral Ohio, hatching-year herring and ring-billed gulls are typically first observed at landfills in July, with increased numbers observed through at least October (Belant et al., 1995).

As determined in this study and previously (Gabrey et al., 1993; Dwyer et al., 1994), urban populations of nesting ring-billed and herring gulls depend (at least in part) on landfills as sources of food. Radio-marked gulls in this study used primarily three landfills, at distances up to 26 km from their respective nesting colonies. Provided that availability of food at these landfills and colony sites are not limited, populations of nesting gulls are likely to increase. Efforts to reduce urban nesting should focus in part on reducing the availability of anthropogenic food, particularly at landfills. Although gulls are federally protected under the Migratory Bird Treaty Act, attempts have been made (under Federal permits) to reduce roof nesting by removal of nests and eggs. Results of these removal programs, particularly with herring gulls, often have limited success in eliminating the problem (Blokpoel and Tessier, 1992; Ickes and Belant, 1998). To effectively manage urban gulls, local planning commissions, affected businesses, and wildlife professionals must coordinate efforts to develop an integrated management strategy (see Belant, 1997). In addition, continued research on harassment and exclusion techniques to reduce urban nesting by gulls is required (e.g., Belant and Ickes, 1996, 1997).

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References

Belant, J.L., 1993. Nest-site selection and reproductive biology of roof- and island-nesting herring gulls. Trans. N. Am. Wildl. Nat. Resour. Conf. 58, 78–86.

Belant, J.L., 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning 38, 245–258.

Belant, J.L., Dolbeer, R.A., 1993. Population status of nesting laughing gulls in the US, 1977–1991. Am. Birds 47, 220–224.

Belant, J.L., Ickes, S.K., 1996. Overhead wires reduce roof-nesting by ring-billed gulls and herring gulls. Proc. Vertebr. Pest Conf. 17, 108–112.

Belant, J.L., Ickes, S.K., 1997. Mylar flags as gull deterrents. Proc. Great Plains Wildl. Damage Control Conf. 13, 73–80.

Belant, J.L., Seamans, T.W., 1993. Evaluation of dyes and techniques to color-mark incubating herring gulls. J. Field Ornithol. 64, 440–451.

Belant, J.L., Seamans, T.W., Gabrey, S.W., Dolbeer, R.A., 1995. Abundance of gulls and other birds at landfills in northern OH. Am. Midl. Nat. 134, 30–40.

Belant, J.L., Seamans, T.W., Gabrey, S.W., Ickes, S.K., 1993. Importance of landfills to nesting herring gulls. Condor. 95, 817–830.

Blokpoel, H., Tessier, G.D., 1991. Distribution and abundance of colonial waterbirds nesting in the Canadian portions of the lower Great Lakes System in 1990. Can. Wild. Serv. Tech. Rep. Ser. 117, 16.

Blokpoel, H., Tessier, G.D., 1992. Control of ring-billed gulls and herring gulls nesting at urban and industrial sites in Ontario, 1987–1990. Proc. Eastern Wildl. Damage Control Conf. 5, 51–57.

Boersma, D., Ryder, J.P., 1983. Reproductive performance and body condition of earlier and later nesting ring-billed gulls. J. Field Ornithol. 54, 374–380.

Brown, K.M., Morris, R.D., 1994. The influence of investigator disturbance on the breeding success of ring-billed gulls (*Larus delawarensis*). Colon. Waterbirds 17, 7–17.

Burger, J., 1981. Feeding competition between laughing gulls and herring gulls at a sanitary landfill. Condor 328–335.

Butterfield, J., Coulson, J.C., Kearsey, S.V., McCoy, J.H., Spain, G.E., 1983. The herring gull *Larus argentatus* as a carrier of salmonella. J. Hyg. Camb. 91, 429–436.

Chudzik, J.M., Graham, K.D., Morris, R.D., 1994. Comparative breeding success and diet of ring-billed and herring gulls on South Limestone Island, Georgian Bay. Colon. Waterbirds 17, 18–27.

Conover, M.R., 1983. Recent changes in ring-billed and California gull populations in the western US. Wilson Bull. 95, 362–383.

Cuyahoga County Planning Commission, 1993. Cuyahoga County, OH–SOLID waste management plan, revised draft plan. vol. 1, p. 437.

Dolbeer, R.A., Belant, J.L., Sillings, J.L., 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport. Wildl. Soc. Bull. 21, 442–450.

Dolbeer, R.A., Bernhardt, G.E., 1986. Early-winter population trends of gulls on western Lake Erie, 1950–1984. Am. Birds 40, 1096–1102.

Drent, R.H., 1970. Functional aspects of incubation in the herring gull. Behaviour Suppl. 17, 1–132.

Drury, W.H., Kadlec, J.A., 1974. The current status of the herring gull population in the US. Bird-Banding 45, 297–306.

Dwyer et al., 1994. The role of landfills in the establishment of roof-nesting colonies of herring gulls and ring-billed gulls in northeast Ohio. Fed. Aviation Admin., Washington, DC, p. 31.

Fetterolf, P.M., 1983. Effects of investigator activity on ring-billed gull behavior and reproductive performance. Wilson Bull. 95, 23–41.

Gabrey et al., 1993. Importance of a landfill to a roof-nesting colony of herring and ring-billed gulls in northeastern OH. Federation of Aviation Administration, Washington, DC, p. 27.

Haycock, K.A., Threlfall, W., 1975. The breeding biology of the herring gull in Newfoundland. Auk. 92, 678–697.

Horton, N., Brough, T., Rochard, J.B.A., 1983. The importance of refuse tips to gulls wintering in an inland area of southeast UK. J. Appl. Ecol. 20, 751–765.

Hunt Jr., G.L., 1972. Influence of food distribution and human disturbance on the reproductive success of herring gulls. Ecol. 53, 1051–1061.

Ickes, S.K., Belant, J.L., 1998. Response of roof-nesting populations of herring and ring-billed gulls to various forms of nest destruction. Wildl. Soc. Bull. 26, in press.

Kadlec, J.A., Drury, W.H., 1969. Structure of the New UK herring gull population. Ecol. 49, 644–676.

Kadlec, J.A., Drury Jr., W.H., Onion, D.K., 1969. Growth and mortality of herring gull chicks. Bird-Banding 90, 222–233.

Kihlman, J., Larsson, L., 1974. On the importance of refuse dumps as a food source for wintering herring gulls *Larus argentatus* Pont. Ornis Scand. 5, 63–70.

Kirkham, I.R., Morris, R.D., 1979. Feeding ecology of ring-billed gull (*Larus delawarensis*) chicks. Can. J. Zool. 57, 1086–1090.

Mech, L.D., 1983. Handbook of animal radiotracking. Univ. Minnesota Press, Minneapolis, pp. 107.

Mudge, G.P., Ferns, P.N., 1982. The feeding ecology of five species of gulls (Aves: Larini) in the inner Bristol Channel. J. Zool. (Lond.) 197, 497–510.

Patton, S.R., 1988. Abundance of gulls at Tampa Bay landfills. Wilson Bull. 100, 431–442.

Patton, S.R., Hanners, L.A., 1984. The history of the laughing gull population in Tampa Bay, FL.. Fla. Field Nat. 12, 49–57.

Paynter, R.A., 1949. Clutch-size and the egg and chick mortality of Kent Island herring gulls. Ecology 30, 146–166.

Pierotti, R., 1982. Selection and its effect on reproductive output in the herring gull in Newfoundland. Ecology 63, 854–868.

Pierotti, R., Annett, C., 1987. Reproductive consequences of dietary specialization in an ecological generalist. In: Kamil, A.C., Krebs J., Pullium, R. (Eds.), Foraging Behavior, Plenum Press, New York, NY, pp. 417–422.

Pons, J., 1992. Effects of changes in the availability of human refuse on breeding parameters in a herring gull *Larus argentatus* population on Brittany, France. Ardea 80, 143–150.

Ryder, J.P., 1993. Ring-billed gull. In: Poole, A., Stettenheimt P., Gill, F. (Eds.), The birds of North America, No. 33. Philadelphia Acad. Nat. Sci. and Am. Ornithol. Union, Washington, DC, p. 28.

SAS Institute, Inc., 1988. SAS/STAT User's Guide, Version 6.03. SAS Institute, Cary, NC, p. 1028.

Sibley, R.M., McCleery, R.H., 1983. Increase in weight of herring gulls while feeding. J. Anim. Ecol. 52, 35–50.

Verbeek, N.A.M., 1977. Comparative feeding ecology of herring gulls *Larus argentatus* and lesser black-backed gulls *Larus fiscus*. Ardea 65, 25–42.

Vermeer, K., 1970. Breeding biology of California and ring-billed gulls: a study of ecological adaptation to the inland habitat. Can. Wildl. Serv. Rep. Ser. vol., 12, p. 52.

Vermeer, K., 1973. Food habits and breeding range of herring gulls in the Canadian prairie provinces. Condor 75, 478–480.

Vermeer, K., Power, D., Smith, G.E.J., 1988. Habitat selection and nesting biology of roof-nesting glaucous-winged gulls. Colo. Waterbirds 11, 189–201.

Weaver, D.K., Kadlec, J.A., 1970. A method for trapping breeding gulls. Bird-Banding 41, 28–31.

Zar, J.H., 1984. Biostatistical Analysis, 2nd edn., Prentice Hall, Englewood Cliffs, NJ, p. 718.